Drivers of ASI Thresher Technology Adoption Among Rice Farmers in North West, Nigeria

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Abstract- ***Farming system Agriculture in Nigeria is one of the least mechanised. The situation is not different in rice threshing which has mostly been done manually in the country. ASI thresher technology was introduced to rice farmers in Northwest, Nigeria to improve threshing activity. Hence, this study examines drivers of adoption of ASI thresher technology among rice farmers in the region. The study made use of secondary data obtained from AfricaRice dataset. The data obtained were analysed using descriptive statistics and probit regression model. The findings revealed that while about 84% of the respondents have heard about the availability of ASI thresher technology, only 47.1% of the respondents have got to know about this threshing technology through fellow farmers and/or thresher operators. ASI thresher adoption status remains low as only about 27% of the respondents used the machine for threshing paddy harvested. It was further revealed that socioeconomic, farm, asset, and locational were significant factors driving the adoption of ASI thresher technology among rice farmers in the region. It was therefore recommended that, for adoption of agricultural mechanisation to be more receptive, locational realities or specific social conditions must be considered to aid or increase acceptance of farm mechanisation technologies among smallholder farmers.***

Indexed Terms- ***Mechanisation, Postharvest, Rice farmers, Threshing, Northwest***

I. INTRODUCTION

1.1 Background to the study

Rice is a key cereal playing crucial economic role; feeding almost 50% population of the world (Fahad et al., 2019). Nigeria with estimated paddy production of 8.3MT, followed by Egypt (4.8MT) and Madagascar (4.4MT), is the largest producer of rice in Africa, while estimated milled rice production in Nigeria was at 5.2MT in 2023 (Statista, 2024; Food and Agriculture Organization (FAO), 2021; USDA, 2020). According to PricewaterhouseCoopers (PwC) (2018), 80% of this production is accounted for by the small-scale producers with majority of them in Northern Nigeria. However, the domestic consumption of rice was estimated at 6.8 million tonnes; leaving a gap of 1.9 million tonnes filled by importation (FAO, 2021; USDA, 2020).

This gap is not only a function of underproduction but also a function of what happens to produce after harvest. Farming systems in Africa are the least mechanised; with other regions having mechanised equipment contributing 50 per cent to their farm power, African region only has 10 per cent. According to FAO (2016), out of some regions in the world such as East Asia, Latin America and the Caribbean, South Asia, and Sub-Saharan Africa (SSA), SSA, where Nigeria is located, is the region with the least (10%) with farm mechanisation but the most (65%) with human power for farm operations. Agriculture in Nigeria continue to be one of the least mechanised globally as poor mechanisation in farming system has been associated with loss of fam produce (Kamai *et al.,* 2020; FAO, 2016).

While most post-harvest losses (PHLs) in Europe and North America are related to unsold quantities at or near consumer-level, they generally occur at the farm-level and post-harvest operations in developing countries (Kumar and Kalita, 2017). It was further observed that food problems of most of the developing countries do not only lie with

underproduction but also a function of what happens to food after being produced or harvested. Osabohien (2024) reported that 38% of harvests by households in Nigeria is lost across the value chains. Harvesting and threshing activities have been reported to be critical paddy loss points along rice chains in Nigeria (Castelein *et al.,* 2022). Use of manual threshing worsens loss of grain, labour cost, and paddy contamination and reduce paddy marketability (Ogwuike *et al.,* 2022; Amponsah *et al.,* 2017).

Enhancing rural farming households' livelihoods would remain a mere wishful thinking in developing countries if agricultural technology adoption remains low (Ogwuike *et al.,* 2022; Matemilola and Elegbede, 2017). Rice production and post-production activities are labour-demanding in Nigeria (Adepoju and Obialo, 2022). Agyei-Holmes (2016) reported that farming is increasingly experiencing labour supply shortage at critical moments in farming operations. There is need for labour-saving technologies in rice farming activities especially at moments when labour-need operations are competing.

ASI thresher technology was introduce to address some of these challenges in rice threshing. ASI is an acronym derived from the collaborative and adaptive research of AfricaRice Center (WARDA), SAED (Extension Authority for the Senegalese River Valley), and ISRA (Senegalese Institute for Agricultural Research) (Ogwuike *et al.,* 2020; Diagne *et al.,* 2009). It was developed to replace the traditional threshing techniques such as drum-beating, stick-beating, etc. which are not efficient (Ogwuike *et al*., 2020). This machine is portable; can be transported to farms on a trailer or van. In Nigeria, ASI thresher is mostly fabricated by the indigenous company called Hanigha Nigeria Limited. Its introduction was done through the Innovation Platforms (IPs) to rice farmers under the auspices of SARD-SC in 2015. It was then supplied freely to rice farmers under the innovation platform organized by SARD-SC/AfricaRice after receiving training on its operations in Kano State in 2015. This post-harvest technology has then spread to other States such as Jigawa and Kebbi through other platforms such as Competitive African Rice Initiative (CARI), government and personal acquisitions.

Although every agricultural technology is unique in its operation, performance and social acceptance, most empirical studies have focused more on production technologies (Zegeye *et al.*, 2022; Awotide *et al.,* 2011). However, this study focused on post-harvest technology (ASI thresher) in rice production. The adoption status and factors driving adoption of ASI thresher among rice farmers still remain unclear in Northwest, Nigeria where it was introduced. Hence, empirical evidence to understand situations around its adoption becomes critical to further guide policy interventions in rice subsector. To answer some of the issues raised aforetime, the following research questions were put forward: What is the ASI thresher technology adoption status of rice farmers in region where it was introduced? What drive the adoption of ASI thresher among rice farmers in the area?

Conceptual framework

As shown in Figure 1, the intervention in this study is the introduction of ASI thresher technology to rice farming. This machine which is locally produced (local fabricators) is either provided by research institutes (For example, AfricaRice, Competitive African Rice Initiative-CARI, *et cetera*), wealthy individuals or government. The threshing service is being made available by thresher operators/owners. The uptake of the threshing service is dependent on certain factors such as socioeconomic (age, gender, household size, *et cetera*), farming (years of farming experience, yield, farm size, cost of transportation to farm, *et cetera*), institutional (association membership, extension contact, government support, et cetera), asset ownership (For example, livestock), locational (For example, states of residence of rice farmers), and unobservable (For example, level of motivation, emotional state, managerial ability, social norms, *et cetera*) factors.

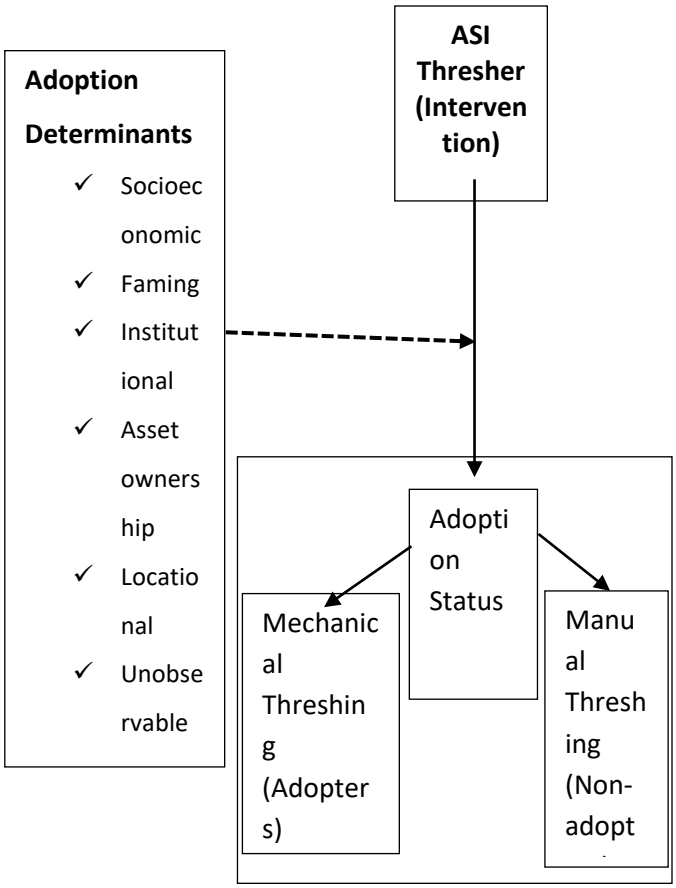


Figure 1: Conceptual framework: Drivers of ASI thresher adoption.

Source: Author's compilation, 2024. Note: Dotted line represent factors influencing outcomes of interest while unbroken lines indicate links between variables

II. MATERIALS AND METHODS

Scope of study

The study was carried out in three States (Kano, Jigawa, and Kebbi) out of seven states in North West, Nigeria. This is because they are rice-producing states with presence of ASI threshers. It is the highest rice-producing region in Nigeria as it contributes 72% of the total rice production in the country (Odey *et al*., 2020).

Type and source of data

Secondary data sourced from AfricaRice was used for this study. The data was collected on rice-farming households using a detailed semi-structured questionnaire in 2018/2019 rice production and threshing data. Data extracted include: demographics, rice farming, threshing, and institutional information.

Sampling procedure

A multistage sampling procedure was employed in the data collection by the AfricaRice Centre for rice production season in 2018/19. In the first stage, the States: Kano, Jigawa and Kebbi were purposively selected due to the availability and use of ASI thresher for rice production. The second phase was the purposive selection of Local Government Areas (LGAs) based on the LGAs having the ASI thresher in the selected States. In total, 9 LGAs were selected: 5 LGAs (Bunkure, Garun Malam, Warawa, Kura and Dawakin Kudu) from Kano, 1 LGA (Auyo) from Jigawa and 3 LGAs (Argungu, Suru and Birnin Kebbi) from Kebbi. The third stage was the randomly selected villages in each LGA; with two villages being selected from each LGA resulting to 18 villages. In the fourth stage, rice farmers were randomly selected from each village. The number of respondents selected from each village was proportional to the size of rice farmers in each village based on the guidance or information provided by Agricultural Development Programme (ADP) Officers in the State. On average, about 80 respondents were selected from each selected LGA. In total, there were 720 respondents but 717 sample-size was used for analysis due to incomplete information.

Analytical techniques

The stated objectives were analysed using analytical tools such as Descriptive Statistics, Probit regression, and Likert Scale.

Probit regression model: estimating factors influencing adoption

Probit regression was used to examine the factors influencing adoption of ASI thresher among rice farmers. It involves binary decision choice either to take up ASI thresher or not for rice threshing and this is subject to certain determinants. Following Olagunju *et al.* (2019) and Awotide *et al.* (2016), standard probit model was implicitly expressed as:

$$\Pr(A_i = 1|X_i) = \theta(X_i\beta_i, \varepsilon) \quad (1)$$

Where A_i indicates farmer's decision status to use or not to use ASI thresher technology to thresh

harvested paddy. It takes the value of one (1), if the farmer uses ASI thresher technology to thresh harvested paddy and zero (0), if otherwise; subject to certain influencing factors. Where, Pr represents probability; θ signifies the Cumulative Distribution Function; X_i denotes a vector of covariates such as socio-economic, household asset, farming, institutional, and locational factors; and ε represents error term. In the independent variables, Kano State was chosen as a base category because it is an intervention state. Explicitly, the probit model was expressed as follows:

$$Pr(A_i = 1|X_i) = \infty_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \cdots + \beta_n X_n + \varepsilon_i \quad (2)$$

Dependent variable

A_i=ASI thresher adoption status (used=1;otherwise=0)

Independent variables

Socioeconomic Characteristics

x_1=Age of rice farmers (Years)

x_2= Household size (Number)

x_3=Sex of rice farmers (Male=1,female=0)

Farm Characteristics

x_4=Years of experience in rice farming (Years)

x_5=Rice farm size (ha)

x_6=Cattle ownership (Owned cattle=1;otherwise=0)

x_7=Awareness of ASI thresher (Aware=1;Otherwise=0)

x_8=Cost of transportation from residence to rice farm (N)

x_9=Quantity of paddy produced (kg)

Institutional Characteristics

x_{10}=Farmer association (Member=1;otherwise=0)

x_{11}=Contact with extension agents (Yes=1,no=0)

Locational Factor

x_{12}=ASI thresher within a community (Available=1;otherwise=0)

x_{13}=States of residence (base=Kano State)

Other Model Parameters

∞_0=Constatnt

β_1-β_13=Estimated parameters

ϵ_i=Error term

III. RESULTS AND DISCUSSION

Distribution of ASI thresher adoption status of rice farmers by socioeconomic characteristics

The description of the socioeconomics of the rice farmers was presented in Table 1. In relation to household characteristics, there was no significant difference between the ASI thresher adopters and non-adopters except in age. On the average, age of ASI thresher adopters was higher than non-adopters by almost 2 years and this is statistically significant at 10%. There was no significant difference in the household size and level of education between the adopters and non-adopters of this technology. This suggests that their socioeconomic characteristics might not really be important in determining their adoption status.

The results showed that rice farming activity across adoption status had more male than female. In total, 93.7 percent of the rice farmers were men. This implies there were more men than women in rice farming in this region. This could be associated with resource requirements and labour-intensive nature of rice farming (For example, planting, harvesting and threshing) which put women at a disadvantage. In addition, there are regional differences in rice farming gender participation in Nigeria. For example, in Northwest, Nigeria, men are more involved in rice farming activities than women (Adam *et al.,* 2018) while women are more involved in planting and threshing in South East (Ebonyi State), Nigeria than men (Edeogbon *et al.,* 2019). The overall average age of rice farmers was about 39 years with majority within the age range of 30-39 years. This suggests that most of the rice farmers are still in their economic and productive age. This age advantage could aid understanding of new developments or good practices in agriculture. This is similar to the findings of Edeogbon *et al.* (2019) in Ebonyi state revealing that the average age of rice farmers was about 39 years.

In respect to educational status of these farmers, it is shown that most (36.8%) of the rice farmers attained secondary level of education with adopters and non-adopters having about 38% and 36.4%, respectively. The mean year of education of the rice farmers was 7.58±5.14. Rice farmers with tertiary level of

education were limited to about 11%. This suggests that people with higher level of learning are less likely to be found in rice farming activity in this region. Overall, the average household size was 8.9 persons per household. This is quite above the average household size, 4.7 and 5.1, in Nigeria reported respectively by NDHS (2018), NBS and UNICEF (2022). This could be of benefits to farming activities that are labour-intensive in nature such as harvesting and threshing in rice farming.

Table 1: Distribution of rice farmers by socioeconomic characteristics

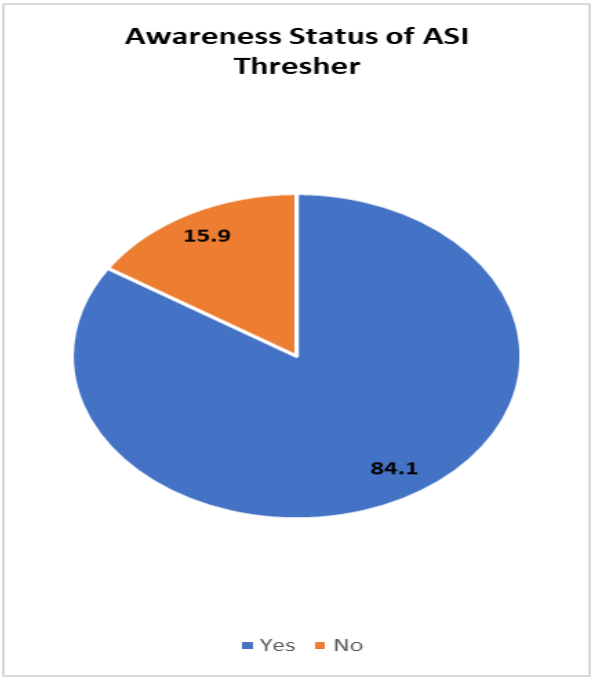
Socioeconomics	Adopters (192)		Non-adopters (525)		Pooled (717)	
	Freq.	Percent	Freq.	Percent	Freq.	Percent
Sex						
Male	176	91.67	496	94.48	672	93.72
Female	16	8.33	29	5.52	45	6.28
Total	192	100.0	525	100.0	717	100.0
Age (years)						
<30	32	16.67	110	20.95	142	19.80
30-39	71	36.98	192	36.57	263	36.68
40-49	44	22.92	127	24.19	171	23.85
50-59	29	15.10	64	12.19	93	12.97
≥60	16	8.33	32	6.10	48	6.69
Total	192	100.0	525	100.0	717	100.0
Mean±Std.		39.8±12.1		38.1±10.8		38.5±11.2
T-test (p-value=0.058*)						
Educational status						
None	15	7.81	100	19.05	115	16.04
Islamic	43	22.40	80	15.24	123	17.15
Primary	37	19.27	100	19.05	137	19.11
Junior high school	14	7.29	31	5.90	45	6.28
Senior high school	59	30.73	160	30.48	219	30.54
College/polytechnic	15	7.81	19	3.62	34	4.74
University	9	4.69	35	6.67	44	6.14
Total	192	100.0	525	100.0	717	100.0
Mean±Std.		8.09±4.87		7.39±5.22		7.58±5.14
T-test (p-value=0.119)						
Primary occupation						
Farming	182	94.79	465	88.57	647	90.24
Employee	1	0.52	11	2.10	12	1.67
Trading	1	0.52	12	2.29	13	1.81
Others	8	4.16	37	7.04	45	6.29
Total	192	100.0	525	100.0	717	100.0
Household size						
1-4	22	11.46	97	18.48	119	16.60
5-8	53	27.60	145	27.62	198	27.62
9-12	46	23.96	107	20.38	153	21.34
13-16	37	19.27	68	12.95	105	14.64
≥17	34	17.71	108	20.57	142	19.80

Total	192	100.0	525	100.0	717	100.0
Mean±Std.		9.6±4.4		8.8±4.7		8.9±4.7
T-test (p-value=0.635)						

Source:Computed from AfricaRice Data, 2024.*represents 10% significant level

IV. AWARENESS AND CHANNELS OF ASI THRESHER TECHNOLOGY IN NORTHWEST, NIGERIA

The information provided in Figure 2 reveals that about 84% of the respondents have heard about the availability of ASI thresher. This implies that about 8 out 10 rice farmers have heard about this threshing technology. In respect to channels of awareness about ASI thresher, 47.1% of respondents got to know about this threshing technology through fellow farmers and/or thresher operators. This means that farmer-farmer and interactions of farmers with the machine operators/threshing service providers have been the best channels through which farmers get to know about the availability of this threshing technology in their locations. Fisher *et al.* (2018) also reported that farmer-to-farmer extension plays a significant role in increasing awareness and adoption of conservation agricultural technologies in Malawi. Furthermore, demonstration of this threshing technology by thresher operators on some farms drive its awareness among rice farmers.



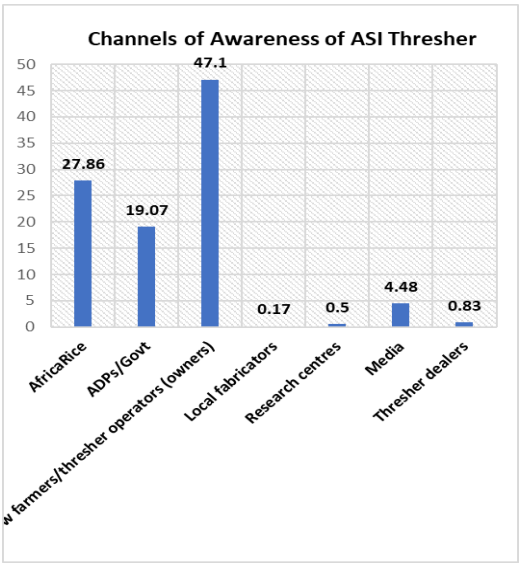


Figure 2: ASI thresher technology awareness and channels of awareness

ASI thresher adoption status of rice farmers in Northwest, Nigeria

Results in Table 2 show that the ASI thresher adoption status remains low as only about 27% of the respondents used the machine for threshing paddy. This means about 3 out 10 farmers used this machine for threshing. Some of the reasons responsible for this low adoption as revealed by the data collected through qualitative means (KII and FGD) include limited number of available threshers to serve a large number of rice farmers, poor knowledge about the advantages of this technology, and social resistance that emerged as a result of the capacity of this threshing technology to reduce number of labour whose livelihood depends on threshing activity. This finding corroborates the findings of Guo and Akudugu (2023), which state that in SSA, adoption of agricultural mechanisation is still very low and is due to some constraints facing it. Guo and Akudugu (2023) also affirm that ignorance of the benefits of the labour-saving technologies among others is contributing to a low adoption rate of farm mechanisation technologies in most developing countries. However, in Senegal where this threshing technology originated from, Ogwuike *et al.* (2020)

reported that about 75% of rice farmers have adopted this technology for rice threshing.

Table 2: Distribution of rice farmers by ASI thresher adoption status

Adoption status	Frequency	Percentage
Yes	192	26.78
No	525	73.22
Total	717	100.0

Source: Author's computation, 2024

Determinants of ASI thresher adoption among rice farmers in Northwest, Nigeria

The determinants of the adoption of ASI thresher adoption are presented in Table 3. The model was statistically significant at 1% indicating that the predictors included were good fit. Thirteen (13) predictors were included in the determinants of decision to adopt ASI thresher from which eight variables (household size, farm size, ownership of livestock, awareness, ASI thresher in a community, quantity of paddy produced, cost of transportation to rice farms, and locational factor) were statistically significant.

The coefficient of household size was significant at 5% but negatively related to adoption of ASI thresher. It reduced chances of adoption by 0.5%. This implies that farmers with large household members are less likely to adopt this threshing technology. This is because large farming households have more family labour (which is cheap and readily available) thereby have more hands available to do manual paddy threshing. Thus, this could be a disincentive to adopting this technology. According to Anderson et al. (2017), smallholder farmers in Nigeria mostly source their labour from family because it is mostly seen as a family business. In addition, household size has a way of reducing cost and hired labour in agricultural production (Awotide *et al.,* 2012).

Farm size has a positive and significant ($p<0.1$) influence on the adoption of ASI thresher technology. A unit increase in rice farm size increased the chances of ASI thresher adoption by 3%. The implication is that rice farmers with larger farm size are more likely to use this ASI threshing technology to thresh their harvested paddy than their counterparts with small farm holdings. Large farms are more likely to produce large quantity of paddy which might be too strenuous and time-consuming for manual threshing thereby opting for threshing technology. Cultivation of large farmland has equally been justified to promote the use of tractor in Africa since farmers with smaller farm sizes see no justification to using tractors on the farm (De Groote et al., 2018; Takele and Selassie, 2018).

Having cattle was positive and significant ($p<0.01$). It increased the likelihood of adopting ASI thresher for paddy threshing by about 18.1%. This is because having cattle is more likely to aid the transportation of ASI thresher technology to farms, where rice threshing takes place. It also reduces the burden or stress of hiring a vehicle of moving it to farms. Hence, rice farmers having cattle, which serve as farm work animals, are more likely to adopt ASI thresher technology. Having cattle as draft animal is therefore complementary to using ASI thresher. In some SSA countries, ownership of livestock was reported to be a positive significant factor driving the use of animal-powered mechanisation (Kirui, 2019).

Having heard about ASI thresher technology significantly ($p<0.01$) promoted adoption of this technology by 13.9%. This implies that rice farmers who heard about ASI thresher technology have higher chances of using this technology for paddy threshing. Creating public awareness has been important to increasing access to resources and opportunities related to mechanisation service especially for the disadvantaged in the society and it is also critical to ensuring behavioural change among them (Etim *et al*., 2022; FAO and Africa Union Commission, 2019).

The availability of ASI thresher in the community where the farmer operates significantly ($p<0.001$) increased the chances of adopting ASI thresher for paddy threshing by 13.7%. This implies that rice farmers who live in a place where this threshing technology is available are more likely to use it to thresh their harvested paddy than their counterparts living in a place without it. Thus, unavailability of

ASI thresher in communities would make it difficult to access its service. This discourages adoption but strengthens the use of traditional (manual) threshing method due to long waiting time.

The quantity of paddy produced significantly ($p<0.001$) increased the likelihood of adopting ASI thresher technology. This indicates that farmers with larger paddy production are more likely to adopt ASI thresher than rice farmers with smaller paddy production. In other words, the higher the paddy production, the higher the adoption of ASI thresher. Higher produce drives the use of ASI thresher because manual threshing would require much stress and time to complete same task. This is in line with the findings of Pingali (2007) who found that demand for mechanised threshing occurred when harvested volumes increased.

Another significant factor driving the adoption of ASI thresher technology was the cost of transportation to rice farms. Surprisingly, this factor was positive and significantly influenced the adoption of ASI thresher. This suggests that rice farmers whose farms were far from town might not easily get labour to manually thresh their harvested paddy due to distance and cost of moving labour to threshing sites. Also, from the responses during the Focus Group Discussion, the farmers stated that when the villages are far, there is a risk of stealing the harvested paddy when it is not immediately threshed.

Although Jigawa State was reported to have the highest percentage of ASI thresher adoption, Kano State was the intervention state of the AfricaRice/SARD-SC. Also, this interventionist has its Innovation Platform in Kano State and the state has the highest number of ASI threshers available among the three states considered. Hence, Kano was taken as the reference (base) state in the category. Being in Jigawa and Kebbi States reduced the probability of adopting ASI thresher for paddy threshing significantly by 6.8% and 16.5%, respectively compared to being in Kano State. By implication, rice farmers in Kano were more likely to use ASI thresher for paddy threshing than their counterparts in Jigawa and Kebbi States. This could be because there were more ASI threshers in Kano State to service farmers in their threshing needs. Kano state was equally an intervention or pilot state; where this innovation was first introduced before spreading to other two states.

Table 3: Probit regression for the determinants of ASI thresher adoption

Variables	Coefficients	Standard Errors	Marginal effects
Age of rice farmers (years)	0.002	0.007	0.000
Household size	-0.022**	0.009	-0.005
Sex (1 if male)	-0.070	0.229	-0.018
Farming experience (years)	0.002	0.008	0.001
Rice farm size (ha)	0.121*	0.066	0.030
Farmers group (1 if a member)	0.158	0.143	0.039
Cattle ownership (1 if owned)	0.599***	0.161	0.181
ASI thresher awareness (1 if yes)	0.719***	0.192	0.139
ASI thresher within a community	0.640***	0.166	0.137
Quantity of paddy produced (kg)	0.000**	0.000	0.000
Transportation cost to rice farm (₦)	0.000**	0.000	0.000
Extension contacts	-0.057	0.161	-0.014
State 2 (Jigawa)	-0.307*	0.196	-0.068
State 3 (Kebbi)	-0.744***	0.174	-0.165
Constant	-2.122***	0.371	
Log-likelihood	-314.516		
No of observations	717		

LR chi2 (14)	101.12		
Prob>chi2	0.000		

Source: Author's computation, 2024. ***, **, and * represent 1%, 5%, and 10% significance levels, respectively.

CONCLUSION

Most effective channels of awareness about ASI thresher have been farmer-to-farmer and/or interactions of thresher operators with farmers. The adoption status of this threshing technology (ASI thresher) among rice farmers is still low. Having large rice farms and produce promotes the use of ASI thresher technology for rice threshing. Cattle ownership enhances transportation of ASI thresher to threshing site thereby increasing its adoption. Proximity (location) to ASI thresher promotes the use of ASI thresher for rice threshing. Those with far distant rice farms are more likely to use ASI thresher than those with rice farms closer to place of residence as labour might be more readily available in farms closer to place of residence. However, large family (household) size reduces chances of adopting ASI thresher for rice threshing. This establishes that labour abundance in a place could discourage adoption of labour-saving technologies as it is seen as something to take away their source of wages (livelihood). Based on the findings of this research, the following recommendations were suggested:

1. The feedback mechanism should be strengthened between farmers or thresher operators and research institutes or local fabricators in order to further enhance adoption and efficiency of this threshing machine since most effective channels of communication about ASI thresher technology have been through fellow farmers and/or interactions with thresher operators.
2. To make agricultural mechanisation more effective, locational realities or specific social conditions must be considered to aid or increase acceptance of farm mechanisation technologies among smallholder farmers.
3. Since having larger rice farms or harvested paddy drives adoption of ASI thresher technology, those with small rice farms or harvested paddy should be encouraged through extension service or incentive to take up this threshing technology.

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